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ORIGINAL STREAMS; AND THEIR RÔLE IN GENERAL DESERT-LEVELING

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Of all continental features rivers seem longest to persist through the geologic ages. The ocean's strand-line freely oscillates as relatively the land-surface rises or sinks, but watercourses flowing to the sea are little disturbed. They may be turned aside; but they usually quickly adjust themselves to the new conditions by merely lengthening or shortening their lower reaches. Some streams, we know, hold their original courses in spite of all orogenic obstacles thrown across their paths. Others conform closely to the local warpings of the earth's crust. Still others greatly extend their valleys by headward growth. But whether antecedent, consequent, or subsequent rivers, they are all directly descended from prior drainage-systems which stretch out indefinitely through geologic time and which even trace back their ancestry to the very beginnings of continents. Nowhere and at no time is there spontaneous generation of new streams or total extinguishment of old ones. Indeed, in a normally humid climate it could hardly be otherwise. In this respect, recorded observation and the necessary consequences of theory strictly accord.

In arid regions there appear to be certain phases of drainage which have no counterpart in moist lands. What little running water there is, is confined mainly to the slopes of the loftier desert ranges. In the mountainous deserts of southwestern United States, for instance, the rivers which once traversed the region and which once were supposed to have carved out the present great valleys are regarded as having long since lost all traces of their courses. With increasing aridity came general withering of streams. Hence only remnantal drainage now seemingly remains. The headwaters of the small intermittent streams are regarded as representing all that is left of former great rivers which have vanished under

the influences of a desiccating climate and as vast volumes of mountain waste deeply filled their valleys to form the present level intermont plains. As these arroyos are looked upon today they are the last vestiges of a once extensive consequent drainage.

In this connection one other point should be briefly noted. The general plains-surface of the region under consideration lies about a mile above sea-level; and above this surface rise another mile the rugged and isolated desert ranges. As in the case of the Great Basin region, it was long the custom to regard the mountain-ranges as tilted and upraised blocks, deeply dissected on all sides from which the resulting waste was carried directly out into the intermont basins. According to this view, the arid climate came over the region while it was already a mountainous country, much as it is today except more deeply sculptured, like the Rockies or the Appalachians are now.

There is another hypothesis applicable to the origin of these streams of the desert ranges; one which more closely accords with the conditions imposed by an arid climate. It is postulated that the mountains are products of differential erosion on an elevated plain composed of alternating hard and soft rock-belts.¹ The erosion of more than 5,000 feet is ascribed to deflation with little or no aid from stream-action.² That wind-scour under favorable conditions is amply competent to accomplish such work, that it is as potent an erosive agent as stream-corrasion and the washings of the rain in a moist climate is fully shown by the recent writings of many observers in various parts of the world, although in this country this subject has not as yet received the attention that it merits. Of these, mention may be made of the work of Obruchew³ in central Siberia, of Walther⁴ in North Africa, of La Touche⁵ in the western Rajputana in India, of Berg⁶ and Ivchenko⁷ in the

¹ *Journal of Geology*, XVII (1909), 31.

² *Bull. Geol. Soc. America*, XXI (1910), 592.

³ *Verh. Imp. min. Gesellsch. St. Petersburg*, (2), XXXIII (1895), 260.

⁴ *Das Gesetz d. Wüstenbildung im Gegenwart u. Vorseit*, 1900.

⁵ *Mem. Geol. Sur. India*, XXXV (1902), 10.

⁶ *Pédologie pour 1902*, p. 37.

⁷ *Ann. géol. min. Russie*, VII (1904), Pt. I, 43.

region about the Sea of Aral and in the Kirghiz steppes, of Pas-sarge¹ and of Davis² in the South African veld, of Penck³ in Palestine, of Hundhausen⁴ in southern France, of Barron⁵ in eastern Egypt, and of Blackwelder⁶ in Wyoming.

The development of the drainage-lines in desert regions under conditions of general deflation is an aspect of arid erosion which has not, so far as I know, received the critical notice that it seems to deserve. Want of special attention to this single point has done more than any other one factor to mislead all who have traveled through the mountainous arid tracts of America, regarding the true ineffectiveness of the stream-erosion. Particularly deluding have been the impressions gained in such lands as those of western America. In many mountainous belts of that region there is, indeed, an apparent approach to normal stream-action as it is known in humid climates. Upon this really quite restricted and peculiarly modified effect of normal stream-work has been based the usual scheme of the arid cycle.

As is well known, the stratigraphy of the northern Mexican tableland, for example, is peculiar and remarkable in that the resistant rocks are mainly segregated in the lower part of the geologic column and the weak rocks in great thickness are confined to the upper part. In pre-Tertiary times chiefly the country was profoundly faulted, the average displacements being between 3,000 and 5,000 feet. As recently shown,⁷ this region suffered planation and uplifting before the imposition of arid climate. If at the beginning of the cycle of aridity the surface were a plain, the present lofty ranges must have been differentially developed through the more-rapid deflation of the broad belts of weak rock now constituting the areas of intermont plain.

As the mountains rear their forms more and more above the general plains-surface while the latter is being gradually lowered

¹ *Zeitsch. d. deutsch. geol. Gesellsch.*, LVI (1904), Protokoll, 193.

² *Bull. Geol. Soc. America*, XVII (1906), 435.

³ *American Jour. Sci.*, (4), XIX (1905), 167.

⁴ *Globus*, CX (1906), 46.

⁵ *Topog. of Sinai, West. Port.*, p. 17, 1907.

⁶ *Journal of Geology*, XVII (1909), 429.

⁷ *Proc. Iowa Acad. Sci.*, XIII (1908), 221.

through deflation, they finally become local rain-provokers of some small influence. During the period of arid youth the streams developed on the mountain slopes become slowly larger and larger, and longer and longer, until as the region is about to pass into its maturity, they attain their maximum size and efficiency. The mountains are now at their loftiest, their sides are steepest, the intermont plain encroaches deepest into them, the moisture gathered about them is greater in amount than at any time before or than will be afterward, the mountain watercourses reach their greatest extension, notwithstanding the facts that they carry relatively little water, are intermittent in character, and their lower reaches seldom pass beyond the foot of the ranges. Instead of being head-water remnants of extensive stream-systems which have long since withered away under the arid climate, as is a necessary consequence of the adapted normal-cycle hypothesis, they must be regarded as original streams coming into being as the differential effects of regional deflation become more and more pronounced. With the advancement of physiographic maturity these streams must begin to wither, and as senile relief approaches, they must, with few possible exceptions, undergo complete obliteration.

It is the custom to regard all water-action upon the desert ranges as normal stream-erosion in the process of dissecting recently upraised orographic blocks. This hypothesis seems to fall at once when it is considered that the major faulting of the mountain-blocks, is as already stated,¹ mainly very ancient, and not modern as has been so long assumed. Certain effects of general deflation have greatly aided in imparting to the mountain sides the infantile aspects of the stream-work. As recently suggested² the locus of maximum lateral deflation in the desert ranges is at their base, where plain sharply meets mountain without the intervention of foot-hills. The hard mountain-rock is encroached upon at the level of the general plains-surface as the sea gnaws away a line of its bordering cliffs, until, in many instances, the surface of the intermont plain extends into the mountain-blocks distances of several miles.

¹ *Bull. Geol. Soc. America*, XXI (1910), 543,

² *Science*, N.S., XXIX (1909), 753.

If the deflative hypothesis of regional desert lowering and leveling be accepted, we have in the desert ranges a stream-type hitherto unrecognized. The streams of this class have had no history previous to the youthful stage of the present geographic cycle, they have no prospect of relations with streams of a later cycle. Their birth, their span of life, their extinguishment are definitely circumscribed. They are the only existing streams we know of that do not have some sort of inherited relations with the waters of previous geographic cycles. They are the only streams the complete life histories of which may be distinctly traced. They are the only streams whose origin is clearly fixed in time and sharply limited in space.